APPLE BLOTCH

By F. M. Rolfs

An old, neglected tree like this is a reservoir of infection from which blotch may spread to nearby healthy trees. Trees of this sort in the vicinity of orchards should be destroyed.

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APPLE BLOTCH

By F. M. ROLFS*

Many of the pioneer settlers of Oklahoma planted family apple orchards. These flourished for a time, and commercial orchards were soon set out. However, as the orchards grew older, the trees showed signs of weakening. Production fell off, many of the trees gradually died, and only remnants of the orchards remained. A close examination of these old trees shows characteristic signs of the blotch disease.

HISTORY

The evidence indicates that the wild crab apple tree is the original host of the blotch organism (12). The apple tree evidently inherited the malady from the wild crab stock. The exact place of origin has not been determined; however, the disease was first recorded by Waite (13) in a photograph of apple from Washington, D. C. in 1895. The evidence suggests that it originated in the orchards of Virginia. Due to climatic conditions and the growth of the apple industry, it spread rapidly to the south and west, seldom developing in its destructive form north of parallel 40. (8).

It was first reported as a major disease of the apple from southern Illinois (1) and Missouri (3) in 1902; from Arkansas (9), Tennessee (10), and North Carolina (11) in 1907; from Oklahoma (7) and Kentucky (4) in 1908; and from Kansas (6) in 1913. The area of infection now extends from New Jersey and Georgia to Nebraska and Texas.

Morris and Nicholson (7) were the first to report blotch from Oklahoma as an important orchard disease but did not indicate its origin. All efforts to establish its origin on a wild host in Oklahoma have failed. Since it has been a common orchard disease in this state for 34 years with evidence of its occurrence only on the apple and pear, it appears quite probable that it was introduced on seedling and nursery stock. If this is the case, it is evident that blotch must have been introduced at least twenty years before it was reported by Morris and Nicholson, or about 1888.

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HOST PLANTS

The blotch organism occurs on the wild crab apple, the pear, and the cultivated apple. The degree of injury on the apple and pear appears to vary somewhat with the host and with the parts of the same host affected. However, the roots, stems, and leaves of the seedling trees serve as carriers of the disease. Individual seedlings do not show marked variation in their resistance to the disease. Nevertheless, there is a constant difference in varieties in the degree of infection. Similar parts of the trees of a single variety consistently develop a similar degree of injury.

A list of varieties very susceptible and slightly susceptible under Oklahoma conditions follows:

Very Susceptible. Arkansas Black, Ben Davis, Cooper's Early, Duchess, Fameuse, Gano, Huntsman, Maiden Blush, Mann, Missouri Pippin, Oliver, Rome Beauty, Roman Stem, Shockley, Smith Cider, Stark, White Winter Pearmain.

Slightly Susceptible. Delicious, Early Harvest, Grimes Golden, Ingram, Jonathan, Ralls Genet, Red June, Stayman Winesap, Starking, Wealthy, Winesap, York Imperial, Yellow Transparent.

SYMPTOMS

The blotch fungus attacks any growing tissue, above or below the ground, producing infections on the leaves, fruit, twigs, limbs, and roots.

1. *On the fruit* the parasite forms characteristic dark blotches from which the disease receives its common name. The infection may develop as a dark, slightly-sunken spot which gradually extends its area until a black, sunken area of considerable size is formed. Tiny black fungous fruiting bodies (pycnidia) usually form abundantly on the surfaces of such areas (Fig. 1). Several distinct infections may occur on a single fruit and finally coalesce, discoloring one half or even the entire surface of the apple. Fruits infected while quite young crack badly.

2. *On the leaf blade* the infection forms white spots less than 1 mm. in diameter, each spot usually having one black pycnidium in the center (Fig. 2). Elliptical lesions 3 to 5 mm. long, each dotted with several pycnidia, are formed on the petiole and mid-rib.

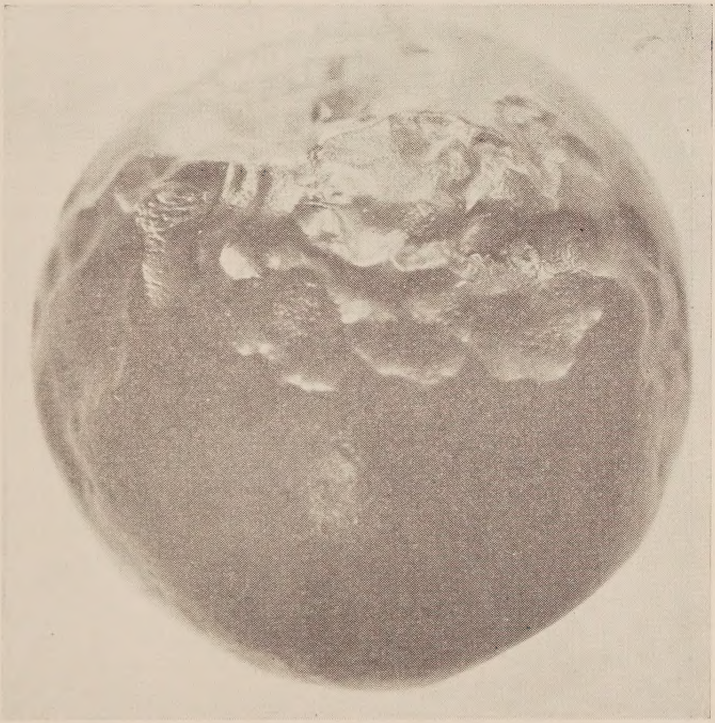

Figure 1.—Blotch on apple fruit.

3. *On the bark* of the current year's growth, cankers first appear as small, dark or black blister-like spots. These gradually enlarge and assume a light tan color; and finally, during the second year, they become gray (Fig. 3). The cankers increase in size from year to year by the extension of the fungus into healthy marginal tissue. Many of the infections may finally coalesce, producing large rough areas on the limbs and trunk of the tree.

4. *On the underground stems, tap root, and large lateral roots,* the behavior of the organism is similar to its behavior on the trunk and limbs. However, cankerous areas on the underground parts are usually dark brown or black, seldom

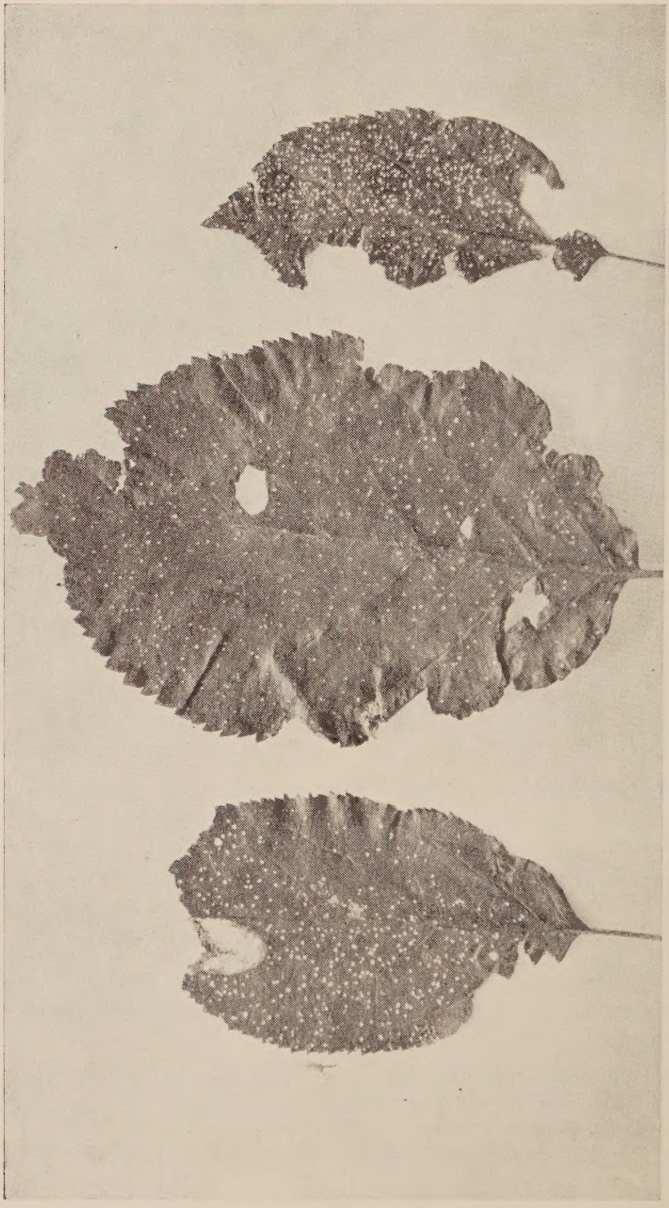

Figure 2.—Blotch on apple leaves.

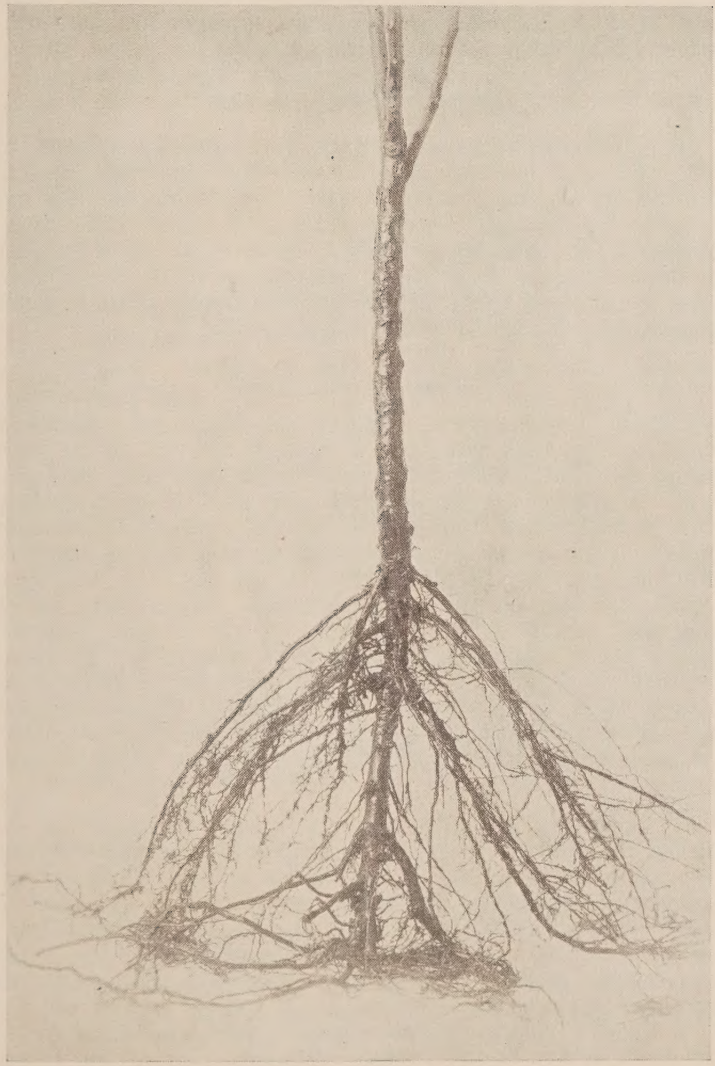

Figure 3.—Infected three-year-old nursery tree, a source of infection for other trees in the vicinity. Note the scaly bark, cankered by the blotch disease. Such trees should be cullled out and destroyed.

assuming the gray color unless exposed to the air for some time. The development of pycnidia is meager and less conspicuous than on parts above ground.

CAUSE OF THE DISEASE

Specimens of the disease were first collected in 1893, by Underwood (12), on the leaves of the American crab apple in Montgomery county, Indiana. They were submitted for examination to Ellis (2), who determined that the causal organism was a fungus of the genus *Phyllosticta,* to which he gave the name *Phyllosticta solitaria.* It was given the name "solitaria" because of the characteristic development of a single pycnidium at the center of each leaf spot.

Growth of the Fungus

The blotch fungus is a parasite that is especially restricted in its food requirements; and in nature it lives, as far as is known, only on the living tissues of apple, wild crab, and pear trees. It produces fruiting bodies (pycnidia) in which microscopic seed-like spores are produced profusely. Under suitable conditions the spores germinate and develop thread-like filaments which invade the living bark, leaves, and fruit, and there branch to form a web-like structure (mycelium) which gradually consumes the cells. The infection kills the cell tissues, which results in the gray cankerous injury on stems and roots, dark blotches on the fruit, and small gray or white spots on the leaves. Small, gray specks of fungous growth soon appear on the surfaces of the injured areas. This growth gradually forms black pycnidia which finally produce large numbers of minute, round, colorless spores.

Temperature, moisture, time, and light intensity have a marked influence on the development of the fungus, and any fluctuations in these factors have a tendency to hasten or retard spore production. The major period for spore production usually occurs shortly after blossoming time. Most of the infections occur within a period about six weeks after the petals have fallen. Heavy precipitation is necessary to swell the pycnidia and aid in the discharge of the spores. A temperature of 77° to 86° F. is most favorable for the discharge of the spores and development of the fungus, although some of the spores will germinate at a lower or higher temperature. A hot, dry July followed by a wet August is accompanied or followed by a second period of spore production. A few pycnidia with mature spores may be found during almost any month in the year.

The fungus makes a slow, persistent growth, but except on the leaves and fruit it does not develop sufficiently during the first season to be detected except by a keen observer. The infections become more evident the second season, and during the third year the cankers become distinct and characteristic.

Its slow but persistent growth, combined with the independent-unit organization of the seedling, nursery, and orchard industries, has permitted a wide and thorough dissemination of the fungus during the past thirty years. Today there is scarcely an old apple tree in Oklahoma that is free of the parasite.

DISSEMINATION

The old, forgotten apple tree, standing in the fence row or on the original family tract, harbors many thousands of the pycnidia in cankers on the twigs and limbs. These pycnidia produce countless spores which are scattered about by the wind and rain. The infected leaves are likewise carried away in the run-off water or blown to considerable distances by the wind. Such trees are a constant menace to the blotch-free seedling and to nursery and orchard trees.

The Seedling Tree

Seedling tree culture under existing orchard conditions in Oklahoma and neighboring states affords abundant opportunity for blotch infection. The succulent, tender tissues of the trees, the cultural methods, and the final sweating process all combine to intensify and extend the primary infestation originating in the old trees.

The area of infection varies more or less with the age of the trees, degree of infestation, height, elevation, slope of the land, wind velocity, drainage, area, etc.

The radius of the circle of infection for wind-blown raindrops from a tree 30 feet high is about 240 feet, with 100 percent infestation in the first 40-foot area. The degree of spread decreases in proportion to the distance from the tree. This area usually becomes greatly extended and very irregular in outline due to run-off water and wind-blown leaves.

The infected dry leaves in the fall may also be carried a mile or more and lodged along fence rows, furrows, rills, and depressions of neighboring fields. Such leaves are often favor-

ably placed for extending the area of infestation by water transport and are also frequently placed conveniently for turning under the following spring to serve as centers of infection for the next year's seedling stock.

The puzzling source of infection of seedling stock growing on newly broken land usually can be traced directly to infected leaves from neighboring orchards. Infected nursery trees and old abandoned seedling stock are likewise constant sources of danger to the clean seedling trees. The seedling sweating process serves to extend and intensify the infection.

In the sweating process, young trees are "lifted" late in October while the trees are still in full leaf. They are usually collected in bundles of a hundred each, without culling for disease. The tops are securely wrapped and tied with a strong twine. The bundles are then carefully placed in a shallow bed or pit in compact, slanting layers, with the tops up. This position usually brings the exposed roots in immediate contact with the leaves of other bundles. The bundles from an infested area become distributed throughout the bed in the bedding process. The bed is finally covered with a layer of loose soil. The temperature and humidity of the bed during the sweating process furnish favorable conditions for spore exudation and vegetative growth of the fungus. The close contact of the diseased leaves and stems in the bundles and the mixing and arrangement of the bundles offer ample opportunity for direct mycelial invasion of the young moist roots and stem tissue. This is especially true if the sweating period is unduly prolonged.

The sweating process is usually completed by late December, when the seedlings are removed from the bed and hauled to the shed for grading and packing. The handling quickly chills the trees and checks the activity of the fungus but does not eliminate the infections. The process tends to make the original stem infections, especially leaf scar invasions, more evident. However, when the leaves have been removed, the most prominent sign of seedling infection has been eliminated, making detection very difficult if not impossible.

The Nursery Tree

Nursery work requires skilled labor and the nursery is usually the best organized unit of the apple industry. It likewise offers the greatest possibilities for infection.

In grafting or budding, there are two direct possibilities of infection, from infected stocks (seedling roots) or from infected scions (twigs). While the stock offers constant possibilities of danger, the scion is an even greater source of infection for the nursery tree.

The infection on the first-year wood is consistently obscure, no matter whether the wood is cut from an old, neglected tree or from four-year-old nursery stock. Culling of wood with spotted leaves is not an entirely reliable means of selecting the scion wood material because stems of twigs with clean foliage in the fall may carry a heavy load of infection. The badly infected spring leaves fall by mid-season and in many such cases the fungus has passed down the petiole into the stem but has not caused sufficient injury to be detected. The leaves which form later may escape infection and be free of the characteristic leaf spot injury. The diseased leaves of both the seedling stock and the scion wood have all been removed before the material reaches the grafting bench, so it is difficult, if not impossible, to detect the presence of blotch during the grafting process.

The scion infection not only doubles the possibility but often increases the degree of infection. The nursery operations offer four possible combinations: (1) the roots and tops may be free of infection; (2) the top and roots may be infected; (3) the top may be free and the roots may be infected; (4) the roots may be free and the top infected. It is evident that the effect of each of the four combinations is quite different. It naturally would be most striking when a graft made from two non-infected members and one made from two infected members are compared. The results might easily be mistaken for resistance and non-resistance. This possibly explains why there is such a variation in the degree of resistance for the same varieties as reported by different writers.

The old diseased orchard trees and the two-, three-, and four-year-old nursery stock also often serve as centers of infection for the healthy nursery trees. The close contact between the infected and healthy trees in shipping and during the heeled-in period likewise offers some possibility of infection. This is especially true if the shipments are held at too high a temperature for a prolonged period of time or if planting is delayed until late spring.

The Orchard Tree

The characteristic canker development usually does not appear until the third year. From then on, the injury gradually becomes more prominent, depending upon the degree of infection. Climatic and soil factors have a marked influence on the activity of the tree, but they have an even greater influence on the behavior of the parasite. Under normal growing conditions, the mycelial threads are restricted to the bark by the formation of a layer of cork cells. However, if the cambium activity is slowed down by excessive dry weather, especially when the trees pass into a semi-dormant state, the fungus in the cankered areas on the older limbs may penetrate into the cambium zone.

The mycelial invasions gradually consume the cambium cells and girdle the limb. Prolonged warm weather in late fall and early winter prolongs the activity of the fungus and materially extends the infected areas.

The more or less protected and shaded lower limbs are constantly exposed to the infection from spores exuding from the pycnidia on the leaves and limbs above. The limbs are finally killed by the combined effect of mass infection on the twigs and leaves below and the aggressive nature of the mycelial threads in the cankered areas.

The dead areas of the trunk and limbs are soon invaded by heart-rot and those of the root by root-rot organisms, which aid materially in the destruction of the tree.

In the final stage of the disease, the tops present a characteristic and desolate appearance. The body has a background of thin, greenish-gray foliage scarcely sufficient to hide the framework of the tree. The dead limbs form a ragged zone of dark gray and black at the base, with a central area of tufted green leaves clustered about the trunk. The area widens more or less upwards and forms a cap-like zone of green leaves at the top.

CONTROL

The obscure yet persistent nature of the development of the parasite and the independent-unit organization of the apple industry have resulted in distribution of blotch over the entire southern apple belt. For the past 30 years blotch has been regarded strictly as an orchard disease. All efforts during this period have been centered on orchard control, and

with some degrees of success. Although considerable relief has been obtained by the use of Bordeaux mixture, it is nevertheless evident from the nature of the disease that complete elimination by this means is impossible.

In the light of present knowledge and experience, the solution of the problem involves not only the infected orchard and old forgotten trees, but all three units of the apple industry: the seedling trees, nursery stock, and young orchard trees as well.

In order to grow clean seedling stock, one must eliminate all infected trees both young and old, or plant the seed on land one-half mile or more from any source of infection. Even if this requirement is complied with, there are still possibilities of the infection finding its way to the tract on diseased stems and leaves. Since leaf infections develop more or less prominently during the first season, the field should be carefully inspected during the months of September and October. At this time of the year many of the spring-infected leaves are still on the tree, and the late season infections have developed sufficiently to be observed. All seedling stock should be inspected before it is placed in the sweating bed. The bed should be located on land that has not been in either seedling trees or nursery stock and which is a safe distance from infected trees. Great care must be exercised not to mix clean and diseased stock and to prevent all infected roots, stems, and leaves from finding their way into the bed. These precautions also apply to the packing shed, especially if the trees are held some time before they are shipped.

The nursery offers a much greater and more difficult problem. While production of clean seedling stock or roots is the first essential step to success, the scion wood is equally important. If it is impossible to secure certified seedling stock in the southern region, the only logical solution is to grow the seedling stock one's self or secure stock from regions known to be free of the blotch organism.

Securing clean scion wood is even more difficult for the nurseryman than securing clean roots. This is especially true at present in the southern region, if the twigs from local trees are used for scion wood. Since evidence indicates that the fungus was introduced into Oklahoma on nursery stock at least fifty years ago, it is reasonable to suppose that practically all susceptible orchard trees carry the infection. After infection once becomes established, it persists in a mild or aggravated

form through the life of the tree. Bordeaux mixture, when consistently and properly applied, will prevent infection on the current year's growth; nevertheless, there is always the possibility of accidental infection, which will not only ruin a single tree but eventually curtail profitable production of the orchard. Even the keenest observer would be unable to certify that the twigs were entirely free of infection. The only safe procedure for the present is to import all scion wood from blotch-free areas. Graft wood from three- and four-year-old nursery stock is likewise of questionable value as far as blotch is concerned.

In addition to the scion wood problem, the nursery, like the seedling industry, has to contend with infected orchard and fence-row trees as centers of primary infection. Every precaution suggested for control of the disease in seedling stock should likewise be observed in growing and handling the nursery stock.

If the young trees escape the infection in the seedling and nursery stages, the old infected family orchard or fence-row trees on the farm may serve as a center of primary orchard infection. While the possibility of infection is greatly reduced on the farm, the time factor greatly increases its probability. All old trees within a radius of one-half mile of the new orchard should be eliminated one year before the trees are set. Varieties show marked differences in their ability to resist the attacks of the disease under Oklahoma conditions. The greatest of care must be exercised in selecting varieties. In starting a new orchard, blotch-free trees are essential for success. Consult your county agent or write the Oklahoma Agricultural Experiment Station for suggestions in planning an orchard.

Successful apple culture in Oklahoma demands a regular spray schedule for controlling not only blotch but other diseases and insects as well. The purpose of spraying and the details on spray materials and time and manner of application are given in the Oklahoma "Orchard Spray Calendar," Circular 168 of the Oklahoma Extension Service, which is available to farmers on request.

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